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ABSTRACT

Using a model of scientific and technical information transfer as a framework, this document focuses on four types of activities: the generation or authorship of telecommunications information and its publication, distribution, and use. Different forms of publication are considered in each functional area, though primary emphasis is on the scholarly journal. An introduction presents a brief discussion of telecommunications and telecommunications information and a model of the formal communications process. Section 2, an examination of information generation, touches on research funding, authors of scholarly communications articles, and costs of authorship, while types of products and services, publishers, and publication costs are covered in section 3. Distribution of information products and services is discussed in section 4, which looks at distribution channels, volume, costs, and secondary products and services. The last three sections examine respectively: (1) information use, including amount of journal reading, use of other materials, use costs, and total system costs and the value of telecommunications information; (2) the role of industry, government, and academia in information and exchange of information among United States and foreign scientists and engineers; and (3) issues in telecommunications area information. Eighteen references are listed. (LMM)

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INFORMATION DISSEMINATION AND TECHNOLOGY TRANSFER IN TELECOMMUNICATIONS

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SECTION 1

INTRODUCTION

1.1 Telecommunications and Telecommunications Information

In support of the considerable volume of telecommunications activity in the United States today, scientists and engineers from a variety of disciplines are performing research and development. The importance of research to the field is heightened by rapid changes in technology and affected by such factors as changes in industry sector, military requirements, and other aspects of the environment. As changes occur, monitoring is required to determine impact on the strength of the U.S. industry and its position in the international competition for telecommunication markets.

Basic to this monitoring activity is an understanding of telecommunications research as it is carried out today and as it might be affected by industrial transition. The purpose of this paper is to analyze the telecommunications information system, the vehicle by which research results are disseminated. Consideration of information activities associated with any field of research provides important indicators of the volume and flow of research results both within the research community and between researchers and industry. By analyzing information patterns, it is possible to determine where research results are generated, where they are used, and how and how freely they are disseminated.

The telecommunications industry is defined for these purposes as including technologies associated with any communication over a distance, including radio, television, telephone, telegraph, and satellite communication. The recent Committee on Energy and Commerce report on the status of competition in the telecommunications area [1] defined the industry in terms of markets in the areas of information and serivces, local distribution, equipment, and long distance. In this report, the industry was estimated at at least $90 billion in revenues.

Research in the telecommunications area is estimated later in this report to be at a volume of about $14 billion for 1982. This involves expenditures by government, industry and the academic sector in support of new developments in telecommunications. An estimated 140,000 researchers are involved in carrying out these efforts in the various sectors. Due to the broad scientific subject matter relevant to the telecommunications field, these researchers come from across the fields of science and technology, with large concentrations from electrical engineering, other areas of engineering, and computer science.

1.2 A Model of the Formal Communications Process

The transfer of telecommunications information takes place within the broader framework of all scientific and technical information transfer. Processes which are carried out are generally the same throughout the various fields, and the telecommunications field as described above is a multidisciplinary one drawing on many areas of scientific and technical endeavor.

A model of the scientific and technical information transfer model is given in Figure 1.1. This diagram represents an information transfer spiral based on published documents, although some of the functions described in it are applicable to other forms of communication as well, such as through conferences or the communication of bibliographic information through publications or computer searches. The spiral includes ten functions that are essential to complete the transfer of information. These functions were chosen because they appear to be discrete in their representation of the communication processes and in the statistical and economic factors related to these processes.

It is convenient to consider the spiral as beginning at research, which results in generation of knowledge (1). This function is the role of scientists and engineers. Obviously without research results to report, there would be little need for communications media. The quantity of new research results and the amount of subsequent use of them are dependent on the number of scientists and engineers and on the resources expended on research.

As a result of scientific research projects, manuscripts (books, articles, reports) are composed (2). The composition function refers to formal writing,

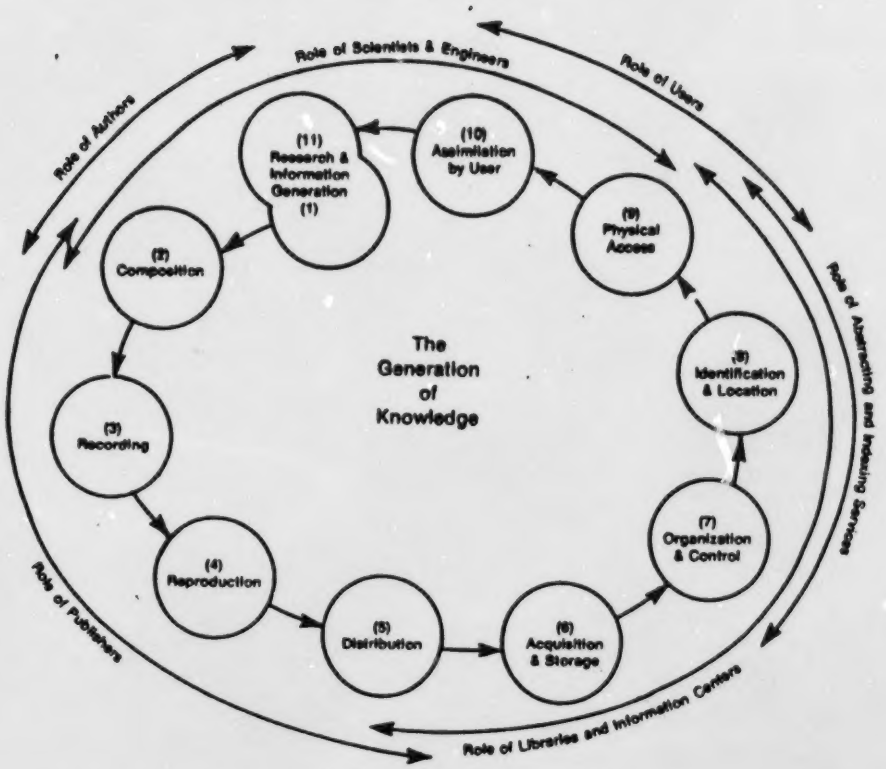

Figure 1.1 Scientific and technical information transfer model

SOURCE: King Research, Inc. [2].

editing, and reviewing of the manuscripts. When a manuscript is in a form to be communicated, it is recorded (3). These two functions are the role of authors, publishers, editors, and reviewers. At this stage authors have as yet very little impact on the scientific community by means of formal communication. Only when the work has been reproduced and distributed does it gain the potential for widespread influence on an audience.

The reproduction (4) and distribution (5) functions are usually the role of the publishers; however, authors, libraries, and colleagues also play an important role. The transfer of documents through the three participants may be thought of as indirect reproduction and distribution, which requires acquisition and storage (6). Although many individuals acquire scientific and technical books, articles, or reports and may store them, this stage of the spiral is represented by libraries and other information centers. Through their acquisitions and storage policies, libraries provide a permanent archive of scientific achievement.* They also ensure access to this record.

Libraries also have an important role to play in organization and control (7) functions. In addition to collecting publications, libraries and other information centers provide access to these documents through cataloging, classifying, indexing, and other related procedures. The major indexing and abstracting services and bibliographic services play an important part in organization and control as well. Needed publications may be identified and located (8) by a number of processes, including reference to one's own subscription, library search, and computerized search and retrieval systems. This function is often accomplished for users by an intermediary from a library or other information service. The physical access (9) function includes direct distribution of scientific and technical articles from publishers to users, indirect distribution through libraries and other information centers, and distribution of reprints by the author. The final function in the spiral, assimilation by the user (10), is the least tangible. It is the stage at which information (as opposed to documents) is transferred. It is at this stage that the state of the user's knowledge is altered.

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* The archive is not restricted to books and journals; it often includes theses, technical reports, patents, convention programs, data bases, and bibliographic publications.

The functional schema is presented as a spiral because the communications process is continuous and regenerative. Through assimilation readers may gain information that can be used in their research in such phases as conceptualization, design, experimentation, and analysis. This research may, in turn, generate new composition and recording for another cycle through the information transfer spiral.

1.3 Description of this Report

This report uses the framework provided in the previous subsection to review the activities associated with the production, distribution and use of telecommunications information. In turn, each of four groupings of activities are considered; that is, those associated with the generation or authorship of telecommunications information, with its publication, with its distribution through libraries, and with its use. In each functional area, different forms of publications are considered. Primary emphasis is given to the scholarly journal as the major means of transmitting research results to the broad scientific and technical community. Other forms of materials covered include other types of periodicals, such as trade journals; technical reports; and books.

Data in the report are drawn primarily from the results of research conducted by King Research, Inc., and others. A major source of information and data was Scientific Journals in the United States [3], which describes in quantitative and qualitative terms the overall scientific and technical communication system in general and the journal system in particular. This book is based on the results of a National Science Foundation-sponsored study to develop a statistical indicators system for describing scientific and technical communication. Other reports from this study also provided methods and data relevant to the analysis of telecommunications information activities.

Data on the telecommunications area in particular came from several sources, including available publications and sources on the industry itself and discussions with industry members, particularly individuals involved in information activities. Data on scholarly journals in the telecommunications area came from an analysis of the major directory in the area, Ulrich's International Directory. Other published sources used are cited as their results are presented.

A major source of data made use of a database generated as a part of the KRI study of scientific and technical journal indicators. This data base contains extensive data on the communication habits of 2,350 randomly selected scientists and engineers obtained via a 1977 survey. Survey topics included extent of authorship, journal leadership, article use, subscriptions behavior, and use of bibliographic and numeric data bases.

To determine activity among telecommunications researchers, survey records were reviewed for indication of an association with telecommunications. In all, a total of 40 such individuals were found, representing about 4.5 percent of all scientists and engineers. Data from these individuals are used to describe the activities of authors and users of telecommunications information in the remainder of this report.

SECTION 2

THE GENERATION OF TELECOMMUNICATIONS INFORMATION

As indicated in Section 1, the scientific research cycle begins with the generation of new information; this new information is then recorded through a variety of mechanisms and disseminated to the scientific community so that it can, in turn, be applied to further research endeavors. In this section we address that essential first step, including the conduct of research and development activities and the generation of new information.

Figure 2.1 illustrates the research cycle from the point of view of the forms of information generated. The figure begins with the initiation of a particular project and continues through the presentation of both oral and written reports and through the creation of secondary publications and listings. The average elapsed time from the initiation of work to the publication of a journal article is about two to two and one-half years, depending on the field. Publication of a book reporting the same results may lag behind publication of a journal article by several years. Although timing is not indicated precisely in Figure 2.1 and not all modes of communication occur in any one instance of reporting of a research finding, the sequence of events does represent that generally found in scientific and technical communication.

Some reports precede the completion of work. These may be oral or written but tend toward informal progress reports, presentations to colleagues, and the like. About 20 percent of the authors of journal articles report preliminary findings in some form.

The majority of prepublication dissemination takes place after work is completed and is ready to be reported. In fact, some 80 percent of authors make one or more prepublication reports, with two-thirds making oral and one-half making written reports, almost half of the authors making both oral and written reports. For all authors, the average number of prepublication reports is 2.4. These figures vary somewhat according to the scientist's field.

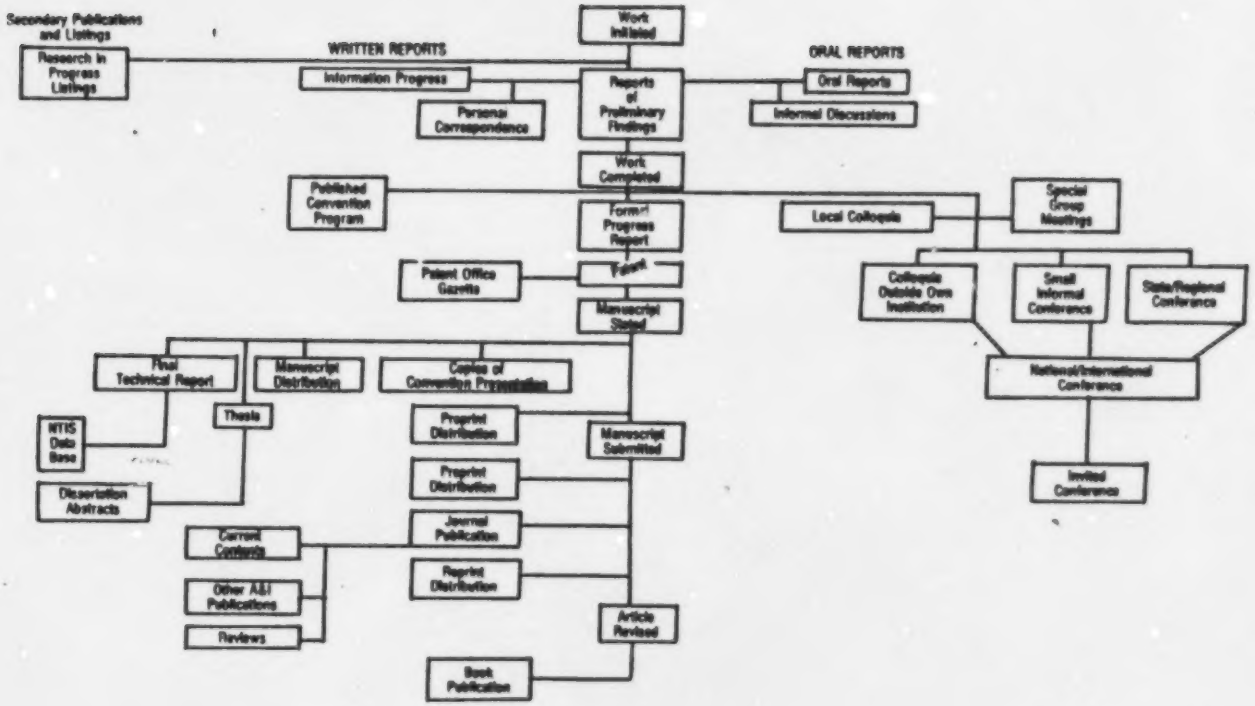


Figure 2.1 The dissemination of scientific and technical research results. Adapted from W.D. Garvey et al., An Overview of the Information Exhcnage Associated with National and Scientific Meetings in Relation to the General Process of Communications in Science (Baltimore: Center for Research in Scientific Communication, Johns Hopkins University, 1970).

SOURCE: King Research, Inc. [4]

The type of oral prepublication report presented ranges from informal presentations, to small, in-house groups, to formal reports given at national or international meetings. Written prepublication reports include personal correspondence, technical reports, theses, in-house publications, patents, proceedings and copies of an oral presentation, and other journal articles. In general, there is a sequential organization of events starting with the more highly focused audiences and ending with the more general ones. This sequence seems especially suited to help authors shape their work gradually and effectively for journal publication. In fact, about half of the authors who made prepublication reports indicate that they received feedback because of those reports, and that this information led them to modify the presentation of their work in the journal manuscripts they submitted later.

Prepublication reports are generally presented or written until the time in a journal article manuscript is submitted for publication. This means that prepublication reporting takes place over about a seven-month period, starting fifteen months before publication.* In the remaining eight months before publication, the primary form of reporting is dissemination of article preprints. These are distributed both before and after article submission and before and after the article is accepted for publication. Somewhat over half the authors of articles distribute preprints at least at one stage; for these scientists, the average number of preprints is slightly less than nine. Like other prepublication reports, preprints are often used as a method of obtaining feedback, which leads to modifications of the journal article.

The first public distribution of research results comes when an article is finally published, some two to two and one-half years after the research was initiated. This period may be somewhat longer if the article is rejected by the first publisher to which it is submitted, and one or more additional submissions are made. By the time of publication, the scientists as authors are likely to have already begun preliminary reporting on their next research venture and possibly to have begun a third piece of research. Thus the time lag between completion of work and formal publication is about the same as a full research cycle.

* Patents are an exception to this time frame. Patient applications are normally filed before journal submission, but the patent itself may not be issued until several years later.

After initial journal publication, the findings may be reported in other journal articles, perhaps as many as eight. Distribution of all the articles takes place over a period of time through personal subscriptions, library copies, or author reprints. Following journal publication, a portion of the research findings are ultimately reported in scientific and technical books. This often happens anywhere from four to thirteen years following the beginning of research.

An additional factor to be noted in Figure 2.1 is the production of secondary publications and listings. These are developed in a variety of formats, and they call attention to the research results at virtually every stage and mode of reporting. Thus they provide a valuable means of access, both prior to and after journal publication, to the literature. In this way, they extend early access beyond a core group to a more general public.

Each of the forms of the published literature reflected in Figure 2.1 are important in the dissemination of telecommunications information. In the remainder of this report, we discuss the activities and costs associated with scholarly journals, other periodicals, reports, and books. Because of the importance of the scholarly journal in this picture, activities associated with this form are covered in more detail.

2.1 Research Funding

Research in the telecommunications area is performed in the government, academic and industrial sectors with funding from each of these sources. The largest volume of research is done by industry.

The industrial category in which telecommunications research is focused is electrical equipment and communications, specifically the communications equipment portion of this. In 1980, of a total of $43.9 billion spent on industrial research, $4.5 billion or 10 percent was spent in the area of communication equipment. [5] Projecting the $4.5 billion to 1982 yields an estimated $5.5 billion on industrial research in telecommunications this year. About 40 percent, or $2.2 billion of this amount is Federally funded and the remaining $3.3 billion is industrially funded.

Total Federal funding for R&D in telecommunications is not identified directly in the available sources. Funding comes from a number of agencies, but predominantly from the Defense Department, including the Defense Communications Agency and Communications Commands in each of the branches of the armed forces. The estimated 1982 budget authority within the Department of Defense for intelligence and communications R&D is $2.2 billion [6]. Drew [7] has identified an additional $72 million in 1981 funding of communications research by civil agencies, giving a total estimate of $2.3 billion. Some of this is expended internally and the bulk goes to fund industrial and academic research.

Because the available data are not strictly comparable, we cannot develop a precise picture of total funding of R&D telecommunications. Given the above, we can conservatively estimate at least $5.5 billion. This estimate is used in the remainder of this report.

2.2 Authors of Scholarly Telecommunications Articles

It is estimated that there were about 5,000 scholarly articles written by telecommunications scientists and engineers in 1982. Out of an estimated total of 55,000 telecommunications scientists and engineers, a relatively small number (4,400) are estimated to write scholarly articles. Nearly one-half of these authors are employed in universities (with 8 percent employed by government, 8 percent employed by non-profit organizations, 33 percent employed by industry and 1 percent are from other situations such as consultants or retired). Not only are there more authors from universities but they are also more prolific in that they average about 5.9 articles per author per year,* whereas the authors from other sectors of employment average beyween one and two articles apiece per year. Even though only 8 percent of the authors come from government, two-thirds of the articles report research that was funded by the Federal government. When an author survey was conducted (1977), there were about 295,000 articles published by U.S. authors in U.S. journals compared to 4,400 articles published in telecommunications at the time. The proportion

* Many articles are co-authored so this number is not reflective of the number of articles published.

of all scientists who authored during 1977 was estimated to be 6 percent which is slightly less than that observed in telecommunications (but a number that is not statistically significantly different).

In some fields, there is a practice of charging authors (or their funders) a fee for publishing an article in a scholarly journal. This more frequently happens with journals published by professional societies. Nearly 70 percent of the scholarly articles published in the field of telecommunications required page charges or some other form of author fees. The average amount of these page charges or author fees was $240 or about $350 in today's value. Across all fields of science, the proportion of articles involving page charges or other author fees is 62 percent and the average amount is $210 (1977) and $310 (1982). Thus, the telecommunication field is somewhat similar to other fields of science regarding page charges. There were no reported instances of authors paying page charges themselves. Rather the charges were paid by the Federal government (39 percent) or the author's employer (61 percent). This also is consistent with the fields of science and engineering in general.

U.S. authors are found to publish scholarly articles in both U.S. journals and non-U.S. journals. Results of an author survey indicate the proportion of articles published inside and outside of the U.S. shown in Table 2.1. Across all fields of science and engineering, about 75 percent of the articles are published in U.S. journals so, again, the field of telecommunications seems to be similar to other fields of science.

As one might expect, telecommunications authors are more frequently found in industry and non-profit organizations than is observed with all scientists and engineers. This is partially because telecommunications is concentrated in physics, computer science and engineering where persons tend to be employed in industry and less so in life sciences, psychology and sociology where persons tend to be employed in universities. However, as shown in Table 2.3, there are some telecommunications scientists employed in most sciences which reflects the multidisciplinary nature of telecommunications.

The level of education of telecommunication authors is similar to all authors from all fields of science as shown in Table 2.4.

TABLE 2.1

PROPORTION OF U.S. AUTHORS WHO PUBLISHED SCHOLARLY ARTICLES IN U.S. JOURNALS AND NON-U.S. JOURNALS: 1978

(Proportion in Percent)

	Published In	
	U.S. Journals	Non-U.S. Journals
University	69%	31%
Industry	71%	29%
Government	86%	14%
Non-Profit	75%	25%
Other	100%	0%
ALL	70%	30%

SOURCE: King Research, Inc., Special Analysis of S&T Author and Reader Survey

TABLE 2.2

PROPORTION OF AUTHORS OF SCHOLARLY TELECOMMUNICATIONS ARTICLES AND ALL SCIENTISTS AND SCIENTISTS BY THEIR SOURCE OF EMPLOYMENT: 1977

(Proportion in Percent)

Source of Employment	Telecommunications	All Scientists and Engineers
Universities	50%	62%
Industry and Non-Profit	41%	19%
Government	8%	15%
Other	1%	4%
TOTAL	100%	100%

SOURCE: King Research, Inc., Special Analysis of S & T Author and Reader Survey

TABLE 2.3

PROPORTION OF AUTHORS OF SCHOLARLY TELECOMMUNICATIONS ARTICLES AND ALL SCIENTISTS AND ENGINEERS BY THEIR FIELD OF SCIENCE: 1977

(Proportion in Percent)

Demographic Characteristics	Telecommunications	All Scientists and Engineers
Field of Science		
Physical Science	15%	14%
Mathematics and Computer Science	25%	4%
Environmental Science	2%	4%
Engineering	48%	15%
Life Sciences	None Reported	32%
Psychology	5%	3%
Sociology	5%	14%
Other	None Reported	14%

SOURCE: King Research, Inc., Special Analysis of S & T Author and Reader Survey

TABLE 2.4

PROPORTION OF ARTICLES OF SCHOLARLY TELECOMMUNICATIONS ARTICLES AND ALL SCIENTISTS AND ENGINEERS BY THEIR HIGHEST DEGREE ATTAINED: 1977

(Proportion in Percent)

Demographic Characteristics	Telecommunications	All Scientists and Engineers
Highest Degree Attained		
Bachelor's (or less)	None Reported	7%
Master's	23%	15%
Doctorage	77%	72%
Other Professional	None Reported	6%

SOURCE: King Research, Inc., Special Analysis of S&T Author and Reader Survey

Authors tend to have more education than non-authors. In fact across all scientists only 17 percent (in 1974) have doctorate degrees.

The authors of telecommunications articles also have substantial experience, as displayed in Table 2.5.

Most of the telecommunications authors are engaged in research, although many are teaching or managing as well. These data are given in Table 2.6.

A higher proportion of the telecommunications authors are managing or conducting research than scientists and engineers found in all fields. This is consistent with their places of employment and the fields of science that they come from.

2.3 The Costs of Authorship

The costs involved in journal authorship are primarily those of time spent by the author or coauthors and by support staff. In some instances, page charges or other fees are also paid by the author and these are considered an authorship cost.

The salaries of telecommunication scientists and support personnel are, of course, significant in determining the cost of authorship. The salaries of scientists are of particular importance, since, as will be seen later, costs associated with their time heavily dominate the total cost of communications. While the makeup of the author community differs somewhat from that of the general scientific community, median salaries are assumed here to be the same for both groups.

The median salary for telecommunication scientists is estimated at about $35,000 in 1982. To convert this to an hourly basis, it is assumed that scientists spend somewhat more than a normal work week in the performance of all their duties, including authorship and research. At an estimated 48 working hours per week, the average 1982 salary is $14.00 per hour.

Authors of telecommunications articles spend, on the average, about 74 hours preparing each article written. This includes time spent in writing the

TABLE 2.5

PROPORTION OF ARTICLES OF SCHOLARLY TELECOMMUNICATIONS ARTICLES AND ALL SCIENTISTS AND ENGINEERS BY THEIR EXPERIENCE IN YEARS SINCE LAST DEGREE: 1977

(Proportion in Percent)

Demographic Characteristics	Telecommunications	All Scientists and Engineers
Years Since Last Degree		
Less than two years	15%	--
2-5 years	15%	--
6-10 years	28%	--
11-20 years	30%	--
Over 20 years	12%	--

SOURCE: King Research, Inc., Special Analysis of S&T Author and Reader Survey

TABLE 2.6

PROPORTION OF AUTHORS OR SCHOLARLY TELECOMMUNICATIONS ARTICLES AND ALL SCIENTISTS AND ENGINEERS BY THEIR PRINCIPAL WORK ROLE: 1977

(Proportion in Percent

Demographic Characteristics	Telecommunications	All Scientists and Engineers
Principal Work Role		
Research	60%	54%
Teaching	20%	27%
Management	18%	13%
Medical Practice	2%	2%
Retired or Not Employed	None Reported	1%
Other	None Reported	3%

SOURCE: King Research, Inc., Special Analysis of S & T Author and Reader Survey

initial manuscript; in editing, reviewing, and rewriting; and in associated activities such as bibliography preparation. Support personnel are estimated to spend an additional 34 hours at $5.70 per hour with 50 percent overhead. The total cost of article authorship is estimated to be $1,850 per article, or $9.3 million over all telecommunications articles.

Additional costs associated with authorship are the page charges and other fees paid by authors or their employers. In the telecommunications area, 70 percent of all articles have an average page charge of $350, for an estimated expenditure of $1.2 million.

Costs associated with authorship of other materials can be estimated using similar procedures. For other periodical articles, the estimated cost is $1,850 per article for 9,000 articles, or $16.7 million. For books, estimated authorship costs are $8,000 per title or a total of $3.4 million. Report authorship costs are estimated at $2,100 per title or $12.2 million in total. Total authorship costs are thus $42.8 million.

SECTION 3

THE PRODUCTION OF TELECOMMUNICATIONS INFORMATION PRODUCTS AND SERVICES

3.1 Types of Products and Services

The principal forms of literature containing telecommunications information are scholarly journals, other periodicals, reports, and books. This section discusses each of these forms briefly. Section 3.2 gives additional information on journal publications, and Section 3.3 covers publishing costs.

A distinction is made between journals and other periodicals. Scientific and technical journals are primary formal vehicles for communicating information and research results. They often employ a peer review or refereeing process to aid in screening manuscripts and for editorial quality control. They also appear in major bibliographic publications and data bases. While their focus is on reporting research findings, methods, concepts, or other scholarly information, they often publish other forms of professional communication such as letters, book reviews, editorials, news, and advertising. Other periodicals (nonjournals) primarily publish less scholarly information such as trade information or news. These other periodicals include bulletins, newsletters, and industrial trade periodicals. It is estimated that in 1982 there are almost 5,000 scientific and technical journals published in the U.S. and about the same number of other periodicals. In the telecommunications area, we estimate that there are about 41 journals devoted exclusively to telecommunications topics and about 74 other periodicals for a total of 115 periodicals. Due to the multidisciplinary nature of telecommunications research, relevant articles are likely to be found in a number of other periodicals. They will in addition be found in periodicals from outside the U.S., the publication of which is not addressed here.

Technical reports are often generated earlier than journal articles reporting research results and may be distributed only within the organization conducting the research or on a broader scale. Reports produced under Federal

funding are generally distributed through Federal information agencies, especially the Defense Technical Information Center (DTIC) and the National Technical Information Service (NTIS). About one report reaches these distribution channels for every $380,000 in Federal research funds, so it is estimated that there are about 5,800 reports generated annually in the telecommunications area. This would not include internal industry reports, the number of which is unknown. The estimated number of reports in the telecommunications area is about 6 percent of all reports generated under Federal funding.

Scientific books are also frequent literature sources for telecommunications scientists and engineers. These may be text books, summaries of the state-of-the-art or research results, or handbook-type publications. In 1982, about 17,500 U.S. books were published in all fields of science and technology. It is estimated that about 420 of these, or about 2 percent, were specifically in the telecommunications area.

3.2 Publishers

It is estimated that there are about 8,200 scholarly journals published in the U.S. in 1982 and about 5,000 are scientific and technical journals. In addition, it is estimated that there are about another 5,000 non-scholarly scientific and technical periodicals which include trade journals, bulletins and newsletters. Through review of Ulrich's International Periodicals Directory, it appears that there are about 41 core scholarly journals and 74 non-scholarly periodicals in telecommunications.

Some characteristics of telecommunication core journals are described below. There are basically five kinds of publishers in the U.S. including professional societies, commercial publishers, industrial organizations (e.g., Bell Laboratories, IBM, etc.) that publish, university publishers and government agencies. The estimated proportion of scholarly journals and other periodicals published by the five types of publishers are given in Table 3.1.

The most dramatic difference between publishing activities of telecommunications and all of science and technology is that a high proportion (24 percent) of core telecommunications journals are published by industrial firms such as Bell Laboratories and IBM. The other difference is that most (69 percent) of the other periodicals in telecommunications are published by commercial publishers. In contrast, across the fields of science more of the other periodicals are published by societies (37 percent vs. 9 percent), universities (10 percent vs. 0 percent), industry (25 percent vs. 21 percent) and government (4 percent vs. 1 percent).

The average age of core journals published in the field of telecommunications is about nineteen years. Even though that seems high, it is less than journals published across all fields of science where the average age is over 25 years. The age by type of publisher is given in Table 3.2.

On the average, telecommunications core journals published by industrial organizations appear to be older (25.7 years) than those published by societies (19.7 years), universities (19.3 years) and government (10 years). Telecommunications journals published by societies and universities are more recent than journals published in all fields of science (29.1 years vs. 19.7 years, and 28.6 years vs. 19.3 years, respectively).

The average circulation of the core telecommunication journals is substantially higher than that of journals published in all fields of science. The average circulation of the scholarly core journals in telecommunication is 15,500 compared to about 6,300 for journals in all fields of science. A breakdown of this number is given by type of publisher in Table 3.3.

TABLE 3.1

PROPORTION OF SCHOLARLY JOURNALS AND OTHER PERIODICALS FOUND IN THE TELECOMMUNICATIONS FIELD AND ALL FIELDS OF SCIENCE BY TYPE OF PUBLISHER: 1977

(Proportion of Percent)

Type of Publisher	Telecommunications		All Fields of Science	
	Journals	Other Periodicals	Journals	Other Periodicals
Societies	29%	9%	39%	37%
Commercial	37%	6%	35%	24%
Universities	7%	--	18%	10%
Industry	24%	21%	2%	25%
Government	3%	1%	6%	4%
TOTAL	100%	100%	100%	100%

SOURCE: Ulrich's International Periodicals Directory: 1981.

TABLE 3.2

AVERAGE AGE OF SCHOLARLY JOURNALS FOUND IN THE TELECOMMUNICATIONS FIELD AND ALL FIELDS OF SCIENCE BY TYPE OF PUBLICATION: 1981

(Age in Years)

Type of Publisher	Telecommunications	All Fields of Science
Societies	19.7	29.1
Commercial	16.2	16.0
Universities	19.3	28.6
Industry	25.7	Not Reported
Government	10.0	Not Reported
ALL TYPES	19.2	25.4

SOURCE: Ulrich's International Periodicals Directory: 1981.

TABLE 3.3

AVERAGE CIRCULATION OF SCHOLARLY JOURNALS FOUND IN THE TELECOMMUNICATIONS FIELD BY TYPE OF PUBLISHERS: 1981

Type of Publisher	Average Circulation
Societies	12,700
Commercial .	21,300
Universities	3,100
Industrial	19,000
Government	Not Reported
ALL	15,500

SOURCE: Ulrich's International Periodicals Directory: 1981.

The journals published by commercial and industry publishers have the greatest circulation. It is interesting to note that the circulation of the journals published by the industrial organizations have such wide distribution.

The prices of the scholarly telecommunications journals and other periodicals were also looked at. The average price for scholarly journals is about $64 and for other periodicals it is $68. This is more than the average price of all scientific journals (i.e., $53). The average price varies substantially by type of publisher.

The average price per journal is by far the highest for commercial journals ($101). It is interesting to note that the price is almost directly correlated (in rank at least) with circulation. That is, the ranking of both price and circulation is commercial (1), industrial (2), societies (3) and university (4). Economic theory would suggest just the opposite; that is, that lower priced journals would have the largest circulation. Thus, other factors such as quality, issues, pages, etc. must come into play. One relevant factor is the average number of issues published per year, which is higher for the more expensive journals (Table 3.5). On the average, there are about 9.6 issues published per journal. From the table it can be seen that journals distributed by commercial publishers have more issues on the average and the highest price and journals published by universities have the fewest number of issues on the average and the lowest price. The one telecommunication journal identified as being published by the government is published annually.

3.3 Publication Costs

To determine publication costs, the different types of material used by telecommunications scientists and engineers are considered separately. The costs of journal publications have been analyzed in detail [8]; also estimated are costs associated with the publications of other periodicals, books, and reports.

TABLE 3.4

AVERAGE PRICE OF SCHOLARLY JOURNALS FOUND IN THE TELECOMMUNICATIONS FIELD BY TYPE OF PUBLISHER: 1981

($)

Type of Publisher	Average Price
Societies	$ 35
Commercial	101
Universities	12
Industrial	64
Government	14
ALL	$ 64

SOURCE: Urlich's International Periodicals Directory: 1981.

TABLE 3.5

AVERAGE NUMBER OF ISSUES PER JOURNAL OF SCHOLARLY JOURNALS FOUND IN THE TELECOMMUNICATIONS FIELD BY TYPE OF PUBLISHER: 1981

Type of Publisher	Average Number of Issues per Year
Societies	7.9
Commercial	13.9
Universities	4.0
Industry	7.7
Government	1.0
ALL	9.6

SOURCE: Ulrich's International Periodicals Directory: 1981.

Costs incurred in journal publishing can be categorized in a number of way, but are most commonly grouped into preruns, runoff, and miscellaneous or other costs. Specific activities related to these three categories are given in Table 3.6. Prerun operations are those necessary before production of the first copy of the journal. Related costs are clearly dependent on the number, size, and complexity of the manuscripts submitted. Runoff costs depend largely on the number of subscribers, and, to a lesser extent, on the number of pages. Miscellaneous activities are generally viewed as incidental to the publication process. These categories account for costs incurred in publishing, not in writing or rewriting manuscripts or in gathering the underlying information.

Key determinants of publication costs include the number of articles published, number of pages, proportion of graphics pages, number of issues, and number of subscriptions. The average telecommunications journal contains about 120 articles per year, with an average length of 4.8 pages per article. The proportion of pages of graphics is quite high, nearly 50 percent. On the average, about 10 issues per year are distributed. The number of subscribers per journal is estimated at 15,500, higher than in most other fields of science.

Incorporating these and other parameters into a cost model yields an estimated annual publication cost of $300,000 per telecommunications journal and a total of $12.3 million for the 41 scholarly telecommunications journals. Publication costs for other periodicals are taken to be about the same as for the scholarly journals, or a total of $22.2 million in all.

To determine book publication costs, we take into account the number of titles published, the average price charged, and the number of copies sold. This underestimates book sales by the profit margin. Estimates for 1982 are for 420 books in the telecommunications area with an average of 1,680 copies sold at a price of $29. Total publication costs are thus estimated at $20.5 million.

Report publication costs are a combination of the costs associated with reports published by the Government, predominantly NTIS and DTIC, and reports

TABLE 3.6

ACTIVITIES PERFORMED IN JOURNAL PUBLICATION

Prerun	Runoff	Miscellaneous
Subject editing	Subscription maintenance	Promotion
Review*	Printing	Advertising
Copy editing	Binding	Conversion to microform
Graphics preparation	Wrapping and mailing	Reprint and back issue sales
Typesetting		
Engraving		
Proofreading		

* Peer review or refereeing.

SOURCE: King Research, Inc. [9].

produced and distributed by R & D performers. In all, an estimated 14,500 reports are produced at a publishing cost of $155, for a total of $2.2 million. Combining costs associated with the publications of journals, other periodicals, books and reports yields an estimated total expenditure of $57.2 million.

SECTION 4

THE DISTRIBUTION OF TELECOMMUNICATIONS INFORMATION PRODUCTS AND SERVICES

4.1 Channels of Distribution

There are a number of participants in the flow of scientific and technical telecommunications information from authors to readers including scientists as authors and users, publishers, secondary organizations, libraries. Each group represents several other participants. For example, authorship includes secretarial, internal editing, and graphics support. Publishers as a participant group includes reviewers, editors, and sometimes outside typesetters, printers, and brokers. Scientists serve both as end users and as intermediaries. Often a scientist will learn about or obtain a journal article from a colleague.

The flow of information among the four types of participants is shown in Figure 4.1. The examination of the flow involved in the system of functions makes it evident that there are many transmissions of information among participants. One can aggregate these transmissions into those that provide flow between participants performing two generic functions such as composition and recording. Most transmission in the composition and recording function include mailing of manuscripts to publishers and transmission of letters and manuscripts back to authors depending on the status of the submitted manuscript. A complete description of transmissions among composition and recording participants is very complex.

Once a manuscript is accepted, the publisher makes a master record and replicates copies in the form of journal issues, reprints, or microform for distribution to users, libraries, and other entities such as abstracting and indexing services (distribution function). The user may read an article upon receipt but normally will store the information for later use. Thus most transmissions of copies from participants in the recording function (publishers) are

to participants in the acquisition and storage function storage function (scientists, libraries, and abstracting and indexing services). Users can obtain information from any one of a number of participants in the acquisition and storage function, including themselves, libraries, and authors. The information can be in several forms, such as journal issues, photocopies, reprints, or microform. Some transmissions are library requests to publishers for copies or subscriptions and reprint requests from users to authors.

When one begins to link all the transmissions for specific messages as they flow from authors to users, several paths together emerge as dominant in the number of transmissions and ultimate uses. One dominant path is from authors to publishers and then to users. Another is from authors to publishers to libraries and then to users. The third is from the author to publishers to authors (reprints) and then to users. The major paths are displayed in Figure 4.1, with all of the principal participants shown as nodes in the flow (scientists as authors, colleagues, and users; publishers; libraries; secondary organizations).

The flow of information from one scientist to another can take a number of paths depending on the basic uses made of the information and the form in which it is transferred. For example, communication can be direct from one scientist (author) to another (user) through path 6 or by a colleague through paths 7 and 14 in the form of informal communication, conferences, or exchange of unpublished technical reports as well as preprints and reprints of published articles. The flow can be through formal publishing in scholarly journals and books, in which case manuscripts will go from authors to publishers (path 1), and the publishers in turn will distribute articles and books directly to scientists (paths 2 and 3) or through libraries (paths 4 and 5), which in turn store and provide the information to scientists (paths 12 and 13). Publishers also distribute copies to secondary organizations (path 8) that abstract and index journal articles. Their publications are distributed mostly to libraries (path 10) that use them for searching, organization, and control. In increasing numbers, libraries rely on other libraries to provide copies through interlibrary loan (path 11). Here we estimate the extent of flow of materials through each of the fourteen paths mentioned above, as well as through other transmissions.

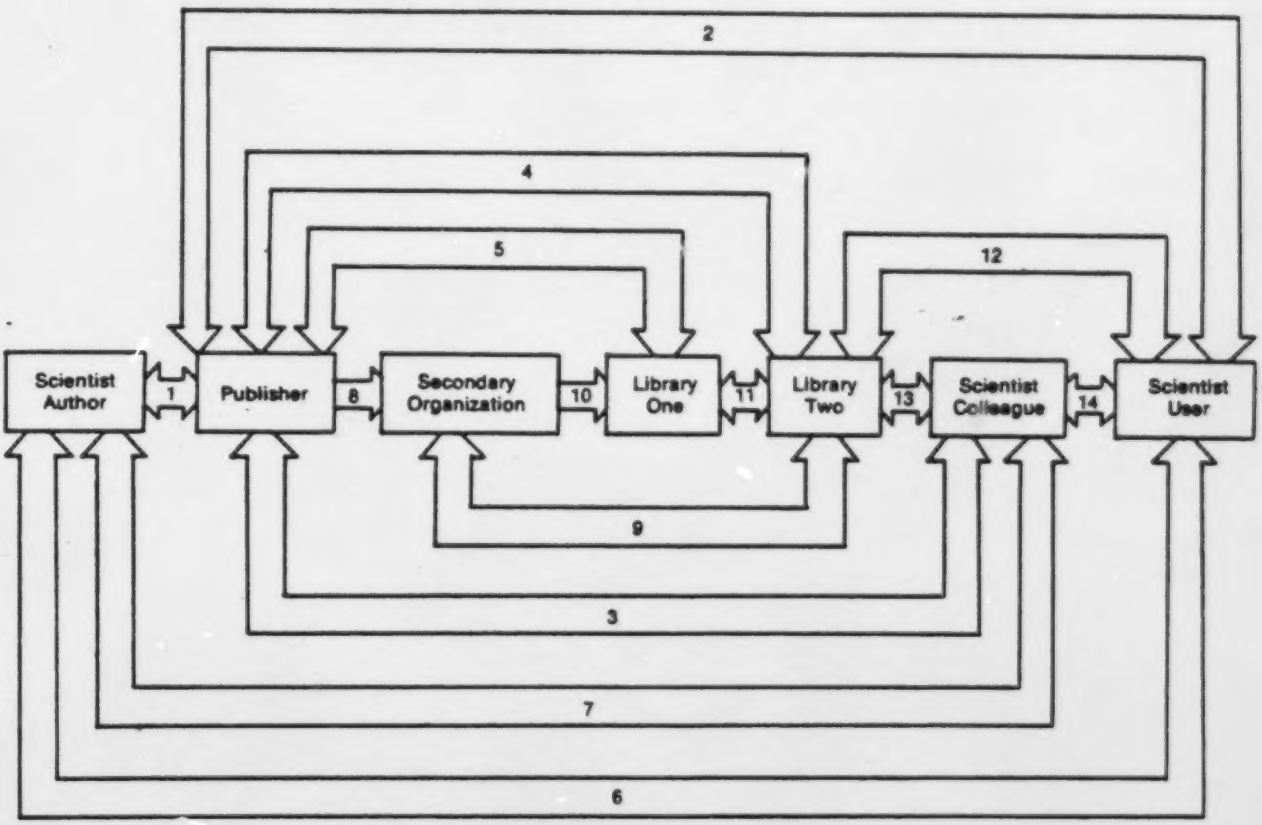


Figure 4.1 General flow of information among scientists and engineers

SOURCE: King Research, Inc. [10].

4.2 Volume of Distribution

If the distribution of journal issues is the same for telecommunication journals as for computer science and engineering journals, the 15,500 average circulation would be subdivided as follows:

U.S. Individual Subscribers	6,200
U.S. Libraries and Other Institutions	6,050
Non-U.S. Subscribers	3,250
TOTAL	15,000

The total number of individual subscribers for the 41 core scholarly journals in telecommunications is about 250,000. This means that the average number of subscriptions per telecommunications scientist or engineer (55,000) is about 4.5 subscriptions.

There are about 4.8 million readings* of telecommunication articles per year. The most clearly distinguishable paths involve readings from the following sources:

- Publishers: Journals or reprints sent from publishers to scientists (users or colleagues).
- Libraries: Journal copies, reprints, or interlibrary loans transmitted from libraries to scientists (users or colleagues).
- Authors: Preprints, reprints, or photocopies transmitted from authors to scientists (users or colleagues).

The number of readings involving each of these three aggregated paths is given in Table 4.1.

It is noted that scientists and engineers engaged in telecommunications research are much less likely than other scientists to get their information

* By readings is meant going beyond the title to the body of the article.

TABLE 4.1

ESTIMATED NUMBER OF READINGS OF TELECOMMUNICATIONS AND ALL SCIENCES ARTICLES BY SOURCE OF ARTICLES: 1982

(millions of readings)

Source of Articles	Telecommunications Readings	Proportion (%)	All Sciences Readings (%)
Publishers	2.1	44%	73%
Libraries	1.5	31%	15%
Authors	1.2	25%	12%
TOTAL	4.8	100%	100%

SOURCE: King Research, Inc., Special Analysis of S&T Author and Reader Survey [11].

from individual subscriptions (i.e., from publishers). This is partially because they receive many fewer personal subscriptions (4.4 subscriptions) than do the other fields of science (about 10 subscriptions). There may be several reasons for this. First, the subscriptions are more expensive on the average ($64 to $53). Second, as mentioned before the field is multidisciplinary and, therefore, the scientists and engineers must depend on a wider range of journals to obtain their information. (More is said about this later because there are implications on how the scientists and engineers find their articles.) Thirdly, the telecommunications articles read tend to be slightly older than other scholarly scientific articles as shown in Table 4.2.

The form of the copies of articles read was usually the actual journal issue (67 percent). Actual reprints accounted for 10 percent of the readings, microform for 8 percent and photocopies for 15 percent.

Readers find their articles in many ways including browsing through an issue (personal or library), hearing about it from another person, citation in an article, citation in a printed index or computer search, or by some other means. Telecommunication readers use bibliographic products and services to a lesser degree than do other scientists and engineers (see Table 4.3).

It is clear that a lower proportion of telecommunication articles read came from formal bibliographic sources (3 percent vs. 24 percent). Only about 2 percent of the telecommunications scientists and engineers conducted online bibliographic searches and another 5 percent had such searches performed for them over the past two weeks. The reason for this evidence of low bibliographic use is not known except there may not be a good source of telecommunication bibliographic data. The information may be found across a number of printed indexes or computer data bases, making it hard to search.

TABLE 4.2

DISTRIBUTION OF TELECOMMUNICATIONS AND ALL SCIENCES ARTICLES READ BY AGE OF ARTICLES: 1977

(Proportion in Percent)

Age of Articles Read	Proportion of Telecommunications Readings (%)	Proportion of All Scientific Readings (%)
1-2 years	71%	82%
3-4 years	13%	4%
5-9 years	13%	11%
Over 10 years	3%	4%

SOURCE: King Research, Inc., Special Analysis of S & T Author and Reader Survey [12].

TABLE 4.3

PROPORTION OF PROCEDURES USED FOR FUNDING ARTICLES READ BY TELECOMMUNICATIONS SCIENTISTS AND ENGINEERS AND ALL SCIENTISTS AND ENGINEERS: 1977

(Proportion in Percent)

Procedures for Finding Articles	Proportion of Telecommunications Readings (%)	Proportion of All Scientific Readings (%)
Browsing in Issue	33%	40%
Another Person	26%	18%
Cited in Article	22%	11%
Bibliographic Source	3%	24%
Other	15%	6%

SOURCE: King Research, Inc., Special Analysis of S & T Author and Reader Survey [13].

4.3 Secondary Products and Services

Abstracting and indexing (A & I) services play an important role in scientific and technical information transfer by providing the intellectual analysis and organization of the scientific literature that gives scientists and engineers the effective access they need for their research activities. Although they concentrate primarily on the journal literature, A & I services treat all literature to some extent and provide scientists with current awareness of materials relevant to their fields of interest, as well as guides for retrospective search of the world's literature.

A & I services are provided by organizations widely varying in the nature of their sponsors and in their sources of funds but generally producing similar products. The traditional product is a periodic publication listing items considered, often with abstracts, and accompanied by appropriate indexes. In the development of the traditional product, a number of organizations have created machine-readable data bases containing similar information that can be used to provide index services directly to persons searching on-line. The growth of such services has been substantial in recent years, which may suggest correspondingly less emphasis on the printed A & I product in the years ahead as printed materials are replaced by on-line searches.

In the telecommunications area, the major U.S. abstracting and indexing service products used by scientists and engineers are those of the National Technical Information Service, Chemical Abstracts Service, Engineering Information, Inc., the Institute for Scientific Information and ABI. Each of these data bases has a broad scope, part of which is relevant to telecommunications research. Several other U.S. databases have at best some information relevant to the telecommunications area. In all, an estimated total of 4,200 items containing telecommunications information are covered by U.S. data bases. Among non-U.S. data bases, there are a large number covering some telecommunications information and at least four that are directly relevant. The four include three data bases generated by the French government -- EDF-DOC, PASCAL 145 - Electronics and TELEDOC -- and the British INSPEC B (Electrical and Electronics).

4.4 Distribution Costs

Distribution costs associated with the telecommunications literature are those costs associated with Federal, industrial and academic libraries making these materials available and the costs associated with secondary products and services. Library expenditures per scientist or engineer can be roughly estimated at about $1,000 in 1982; this is a total of $55 million. Costs associated with the estimated 42,000 items in the telecommunications area processed by abstracting and indexing services are $54 per item or $2.3 million. Searching of the resultant data bases adds an additional $10.8 million in costs based on 270,000 searches at $40 each.

SECTION 5

THE USE OF TELECOMMUNICATION INFORMATION

5.1 Amount of Reading of Journals

The total amount of reading by telecommunications scientists and engineers is about 4.8 million readings in 1982. They average reading about 87 articles per year which is less than all scientists (105 articles per year). On the other hand, the average time spent reading by telecommunications scientists and engineers is estimated to be about 100 hours per year compared to 80 hours spent by scientists in general. Thus, more attention appears to be paid to articles that are read by telecommunications scientists and engineers.

The general category of purpose for which an article is read provides an indication of its use and serves as an indirect indicator of journal system benefit. Generally we have classified the purposes of reading into six categories:

- Research: To prepare a proposal or to plan a project, to apply its methodology to a current project, or to apply its findings to a current project.
- Education (Others): To prepare a lecture or presentation.
- Education (Self): For professional development, current awareness, or general interest.
- Writing: To prepare an article, book, review, or report.
- Citation: To cite in a journal article, book, review, or report.
- Management: To use for planning, budgeting, or management of research.

The purposes cited by scientists and engineers in the users' survey are shown in Table 5.1.

TABLE 5.1

PROPORTION OF READINGS BY TELECOMMUNICATIONS SCIENTISTS AND ENGINEERS AND ALL SCIENTISTS AND ENGINEERS BY PURPOSE OF READING: 1977

(Proportion in Percent)

Purpose of Reading	Telecommunications Scientists and Engineers (%)	All Scientists and Engineers (%)
Research Fundings	69%	44%
Research Methods	52%	45%
Research Proposal	14%	17%
Writing	42%	16%
Citation	54%	34%
Self-Education	91%	94%
Other's Education	33%	18%
Management	13%	6%

SOURCE: King Research, Inc., Special Analysis of S & T Author and Reader Survey [14].

Purpose frequently includes self-education (91 percent), applying the article's methods to current research (52 percent), applying the article's findings to current research (69 percent), and citation (54 percent). Overall readers identified an average of almost four purposes of use for each article read -- self-education and about two other purposes. The high proportion of articles read that are directly applicable to current research is somewhat surprising. The level of citation uses is approximately equal to that for writing, when writing proposals is included.

There are more purposes of use cited by telecommunication scientists and engineers than by all scientists and engineers.

5.2 Use of Other Materials

Less is known about the use of materials other than journal articles by telecommunications scientists and engineers. Several studies, however, do provide some indication of the communication habits of scientists and/or engineers generally, and from these we can develop an indication of activity in the telecommunications area.

In a recent study of Information Transfer in Engineering [15], Shuchman asked engineers to indicate the importance of various types of information sources to their work. Results shown in Table 5.2 group the sources considered by kind of information. Use of journals was excluded from the particular questions asked and addressed elsewhere. As shown, journal sources ranked by importance would include internal reports (92 percent moderately or very important); handbooks and tables (80 percent); dissertations, conference proceedings, external reports and data bases (49 percent); and patents (32 percent). Asked about their use of periodicals, 43 percent indicated that they regularly read trade periodicals, and 41 percent indicated that they read scholarly journals.

Another study of engineers by Thomas Allen also looked at the use of different information sources [16]. Here, of all instances of use of literature sources by engineers on development projects, 55 percent were of technical reports, 28 percent were of periodical articles, and 17 percent of books.

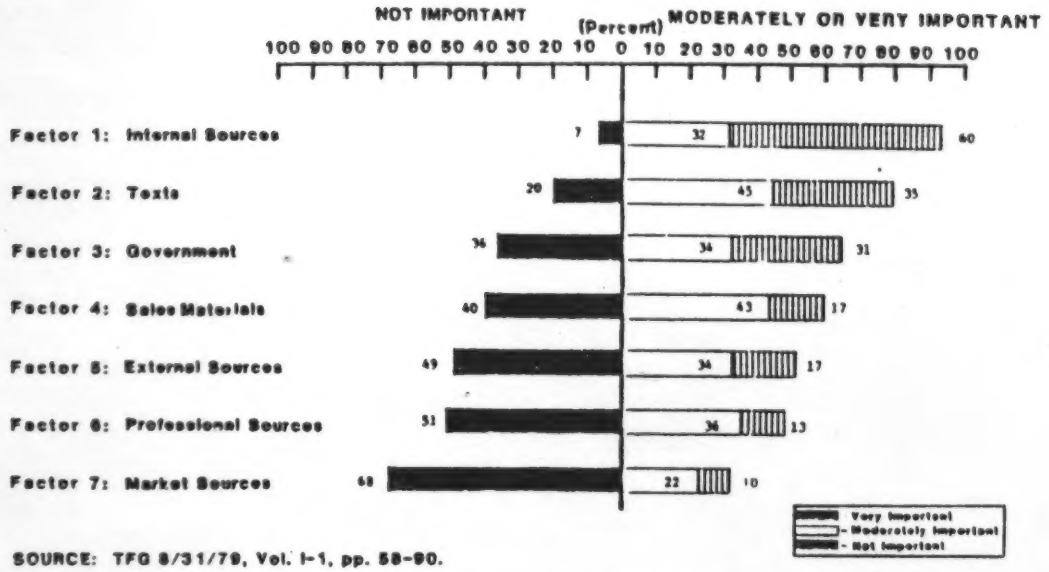
Studies of scientists or of groups including both scientists and engineers tend to show somewhat lesser dependence on technical reports and more on journal articles. In a study of energy researchers, King Research, Inc. found the distribution of use by service indicated in Table 5.3.

The previous section indicated an annual usage of 86 periodical articles by telecommunications scientists and engineers. Based on evidence from other studies as described above, it is assumed that the telecommunications researcher, on the average, also reads or consults 122 articles and 52 books annually.

TABLE 5-2

VALUE OF INFORMATION SOURCES*

All Engineers in Sample N = 1306



SOURCE: TFG 8/31/79, Vol. I-1, pp. 58-90.

*Factors on Q.5. For complete list of sources within each factor, see below

Q.5. Kinds of Information Used

Internal - Factor 1

Conversation with Colleagues
Consulting with Supervisors
In-House Reports

Texts - Factor 2

Handbooks
Tables

Government - Factor 3

Government Departments
Specifications and Standards
Government Regulations

Sales - Factor 4

Manufacturers or Sales Reps
Trade Shows
Catalogs
Advertisements, etc.

External - Factor 5

Former Employees from Other Firms
Universities and Research Organizations
Consultants Outside Firm

Professional - Factor 6

University or Research Organizations
Dissertations
Conference Proceedings
External Technical Reports
Abstracting Publications (data bases)

Market - Factor 7

Customers
Bidders Meetings
Marketing Services/Trade Associations
Patents
Marketing Services

SOURCE: Hedvah L. Shuchman, Information Transfer in Engineering [17].

TABLE 5-3

USE OF INFORMATION SOURCES BY ENERGY SCIENTISTS AND ENGINEERS: 1982

	Number of Uses Annually (millions)	Proportion of All Uses
Periodicals	7.1	41%
Reprints	6.6	38%
Books	3.8	22%
TOTAL	17.5	100%

SOURCE: King Research, Inc., Based on The Value of the Energy Data Base [18].

5.3 Use Costs and Total System Costs

The cost of using the telecommunications literature reflects the time spent by the researcher in reading the various sources. Table 5-4 derives estimates of these costs. First, the number of uses annually per researcher is given based on data from the previous sections. Time per use, taken from the same sources, is also shown. These are combined to give the total time per researcher, an estimated 321 hours annually or 13 percent of the time spent working. The next column gives the total time for all of the 55,000 scientists and engineers in the telecommunications field, and the final column converts this to monetary terms by multiplying by an hourly salary of $14 plus 50 percent overhead. The resultant total use cost of $374 million dominates the costs associated with communication activities in the telecommunications field.

The components of these total costs are shown in Table 5-5, drawing from estimates reported earlier. Costs are shown by function and by type of material. The total cost is over $500 million, a significant proportion of the $5.5 billion spent on telecommunications R&D. Of the total expenditures, about two-thirds are associated with reading, 13 percent with distribution, 8 percent with authorship, and 11 percent with publication. By type of material, report-related activities account for 46 percent of total expenditures, journals and other periodicals for 34 percent, and books for 19 percent.

Another aspect of total expenditures for telecommunications information is the source of funds. Table 5-6 allocates research-related costs (authorship and use) according to the source of research funds. Library distribution costs are similarly allocated, while publication costs for primary and secondary materials are associated with the sector carrying out the publication process. Using this approach, expenditures of $303 million by the telecommunications industry and universities, $196 million by the Federal government, and $43 million by other groups are estimated.

TABLE 5-4

NUMBER AND COST OF USES OF INFORMATION SOURCES BY TELECOMMUNICATIONS SCIENTISTS AND ENGINEERS: 1982

Type of Material	Number of Uses Annually per Researcher	Time Per Use (hours)	Total Time per Researcher (hours)	Total Time All Researcher (millions of hours)	Total Use Cost (millions of dollars)
Periodicals	87	1.0	87	4.8	$101
Reports	122	1.5	183	10.1	212
Books	52	1.0	52	2.9	61
TOTAL	261	--	321	17.8	$374

SOURCE: King Research, Inc.

TABLE 5-5

EXPENDITURES FOR TELECOMMUNICATIONS INFORMATION
BY FUNCTION AND TYPE OF MATERIAL: 1982

(millions of dollars)

Function	Periodicals	Reports	Books	TOTAL
Authorship	27.2	12.2	3.4	42.8
Publication	34.5	2.2	20.5	57.2
Distribution	23.8	23.8	20.5	68.1
Use	101.0	212.0	61.0	374.0
TOTAL	186.5	250.2	105.4	542.1

SOURCE: King Research, Inc.

TABLE 5-6

EXPENDITURES FOR TELECOMMUNICATIONS INFORMATION BY FUNCTION AND SECTOR: 1982

(millions of dollars)

Function	SECTOR			TOTAL
	Federal Government	Industry and Academic	Other	
Authorship	17.1	25.7	--	42.8
Publication	1.9	12.0	43.3	57.2
Distribution	27.2	40.9	--	68.1
Use	149.6	224.4	--	374.0
TOTAL	195.8	303.0	43.3	542.1

SOURCE: King Research, Inc.

5.4 The Value of Telecommunication Information

The telecommunication field currently expends about $5.5 billion annually on research and development. The return on this investment to the nation is basically achieved through the accomplishment of the specific goals and objectives of the R & D and through use of the knowledge gained from the R & D. There is abundant evidence that telecommunication information plays an important role in current research and development activities. A survey of the scientists and engineers shows that annually they read about 4.8 million journal articles.

The telecommunication information found in readings of articles and technical reports is used for many purposes, including application to research, management, and education of self and others. It is emphasized that the information acquired through reading helps teachers convey more extensive knowledge, scientists and engineers perform better research, and management make better decisions. Clearly, use of existing information saves researchers considerable time and effort. In a survey of scientists and engineers, many indicated that a recent reading of a technical report or article led to a savings of time and/or equipment. A wide range of savings values were reported for 40 percent of article readings. Over all readings of articles, there was an average savings of $450 per reading.

The total annual savings attributable to reading of articles by telecommunications scientists and engineers is estimated to be about $2.2 billion. This is one estimate of the consequential value of primary energy information found in articles. Similar estimates can be developed for the value of reading of other types of materials. It is clear that information products and services can substantially help achieve such return on R & D investment through providing better information and increasing use of information.

SECTION 6

SECTORAL ROLES IN TELECOMMUNICATIONS INFORMATION

6.1 Role of Industry, Government, and Academia in Telecommunications Information

In this section, the relative roles of different sectors are discussed regarding their contribution to telecommunication information transfer. The industry, government and academic sectors contribute to telecommunication information at several levels including:

- Generation of information through research and development expenditures.
- Authorship of telecommunication information.
- Publication of telecommunication information.
- Use of telecommunication information.
- Total contribution of expenditures in the production, distribution and use of telecommunication information.

A summary of the extent of involvement of the different sectors at these levels is given in Table 6.1.

In terms of funding, it is clear that the government is funding a large share (40 percent) of the R & D activities in telecommunications. However, the application of a substantial proportion of the government expenditures is taking place in industry and at universities. The information expenditures reflect the amount of R & D activity and where the funds are being expended. On the other hand, information transfer activities (at least to the extent of scholarly telecommunications journals) varies substantially between authorship, publication and use of information. Authorship is highly concentrated in the academic sector (81 percent of scholarly articles published). The reasons for this may be threefold. First, the kind of telecommunications research performed in universities may lend itself more to publication in the open literature. Even

TABLE 6.1

TELECOMMUNICATIONS INFORMATION ACTIVITIES BY SECTOR: 1982

Sector	Source of R&D Expenditures ($ bil)	%	Information Expenditures ($ mil)	%	Articles Written (000)	%	Journals Published	%	Total Article Readings (mil)	%
Government	$ 2.2	40%	$ 196		0.5	4%	1	2%	0.4	8%
Telecommunications Industry	3.3	60%	303	56%	1.7	12%	10	24%	1.4	30%
Academia	Unknown				11.0	81%	3	7%	2.5	52%
Other			43	8%	0.4	3%	27	67%	0.5	10%
TOTAL	$ 5.5	100%	$ 542	100%	13.6	100%	41	100%	4.8	100%

SOURCE: King Research, Inc.

though much of the government R & D funding is applied by industry, the results do not appear to be made available through the journal literature. It may be that technical reports provide the principal dissemination mechanism for this information. Also, companies may be more reluctant to disseminate research information (even though some is funded by the government) because of the proprietary nature of the information and because some of it may be classified. Finally, there may be greater representation of articles written by scientists and engineers who are employed by industry in the trade literature which is not covered in Table 6.1. It is noted that there are a number of journals published by the telecommunications industry (24 percent) and that proportion is even higher when commercial publishers are excluded and the trade literature is included (51 percent). The proportion of reading of scholarly journal articles by scientists and engineers employed in industry is much higher than authorship (30 percent vs. 12 percent). This holds true to a lesser degree for those employed by government or non-profit organizations.

6.2 Exchange of Information Among U.S. and Non-U.S. Scientists and Engineers

There is some evidence concerning exchange of information among U.S. and non-U.S. scientists and engineers. The following data are discussed in this section:

- Number of U.S. scientists who publish in non-U.S. journals.
- Number of non-U.S. scientists who publish in U.S. journals.
- Number of journals and non-journal periodicals published in the U.S. and elsewhere.
- Number of articles written by non-U.S. scientists that are read by U.S. scientists.

It is estimated that approximately 60 percent of the articles written by telecommunication scientists and engineers are published exclusively in U.S. journals. However, another 32 percent of the articles are published both in U.S. and non-U.S. journals. About 8 percent of the articles written by U.S. authors are published exclusively in non-U.S. journals. It appears that about 28 percent of the articles published in U.S. journals are written (at least

first author) by non-U.S. telecommunications scientists and engineers. Through review of periodical titles in Urlich's it is estimated that there are about 70 scholarly core telecommunication journals published worldwide and about 59 percent of these are published in the U.S. In addition there are about 133 other, non-journal periodicals published worldwide, of which about 56 are published in the U.S. The principal difference in U.S. and non-U.S. publishing is that many more periodicals published outside the U.S. are published by governments. Finally, it is found that about 17 percent of the readings of telecommunication articles by U.S. scientists and engineers were written by non-U.S. scientists or engineers. This small proportion (relative to the number of journals) may reflect the lack of interest in the non-U.S. literature; or it could be that there is less access to the non-U.S. literature.

SECTION 7

ISSUES IN TELECOMMUNICATIONS INFORMATION

From our review of information activities in the telecommunications area, a picture emerges of the current flow of research results from the researcher through publication and distribution channels and back again to the researcher for application in further work. The picture closely parallels that found in other areas of science and technology, particularly in the various fields of engineering.

The primary materials used to disseminate research results include periodicals, technical reports and books. One category of periodicals is the scholarly journal, the major vehicle for communicating with the broad research community. In the telecommunications field, there is a relatively small number of scholarly journals, but these are quite large in size. The proportion of journals produced by industry members is higher than in other fields.

Telecommunications researchers identify materials through a variety of means, including colleague references and use of secondary information products and services. There is less use of secondary information products and services than in other fields. Once identified, materials are obtained through personal subscription and purchases, organization libraries, and other channels such as author and colleague copies. Telecommunications researchers make heavier use of library collections than researchers in other fields.

The amount of time spent annually by telecommunications researchers is about 18 million hours, or 321 hours per researcher. More than half of this time is spent reading technical reports and the remainder on periodical articles and reports. Dependence on the report literature is somewhat greater than in other areas of science and technology. Use includes the reading of materials generated and published in other countries.

Issues identified in the course of our review of the telecommunications information system include the following:

- The dissemination of research results through information products and services is critical to the application of research efforts in the telecommunications industry and to future research efforts. Improvements in the information system can lead to increases in the value obtained from research.

- As telecommunications research generates new developments at an even faster pace, information systems must keep up and disseminate information more rapidly. This may require changes in the current dissemination systems, including the application of the new telecommunications technologies.

- The producers of telecommunications research information include scientists and engineers in the Federal, industrial and academic sectors. Each of these groups necessarily approaches the dissemination of information in a different way. These factors need to be considered in planning for future research activity.

- Current telecommunications research activities are concentrated in a relatively small number of organizations. Information dissemination in this environment includes heavy use of informal, internal communication modes such as discussions with colleagues, internal memos and reports, and so on. If the composition of the research sector enlarges, the need for formal communication via journals and books will increase.

- Constraints on the flow of telecommunications information result from military and industrial restrictions on dissemination and use. The effects of these restrictions on research results and costs needs to be explored.

- There is considerable interaction between the U.S. and other countries in the area of telecommunications information. A careful weighing of the benefits and disadvantages of this interaction in light of the goal of maintaining the U.S. position in telecommunications is appropriate.

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